



US010766836B2

(12) **United States Patent**
Verma et al.

(10) **Patent No.:** **US 10,766,836 B2**

(45) **Date of Patent:** **Sep. 8, 2020**

(54) **METHODS AND SYSTEMS FOR SEPARATING OLEFINS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/210,035**

(22) Filed: **Mar. 13, 2014**

(65) **Prior Publication Data**

US 2014/0275674 A1 Sep. 18, 2014

Related U.S. Application Data

(60) Provisional application No. 61/783,970, filed on Mar. 14, 2013.

(51) **Int. Cl.**

C07C 7/167 (2006.01)
C07C 7/09 (2006.01)
C10G 7/00 (2006.01)
C10G 45/32 (2006.01)
F25J 3/02 (2006.01)

(52) **U.S. Cl.**

CPC **C07C 7/167** (2013.01); **C07C 7/09** (2013.01); **C10G 7/00** (2013.01); **C10G 45/32** (2013.01); **F25J 3/0219** (2013.01); **F25J 3/0233** (2013.01); **F25J 3/0238** (2013.01); **F25J 3/0242** (2013.01); **F25J 3/0252**

(2013.01); **C10G 2300/1088** (2013.01); **C10G 2400/20** (2013.01); **F25J 2205/04** (2013.01); **F25J 2210/04** (2013.01); **F25J 2210/12** (2013.01); **F25J 2215/62** (2013.01); **F25J 2230/30** (2013.01); **F25J 2245/02** (2013.01); **Y02P 30/40** (2015.11); **Y02P 30/462** (2015.11)

(58) **Field of Classification Search**

CPC **C07C 5/08**; **C07C 7/00**; **C07C 7/04**
USPC **585/259**
See application file for complete search history.

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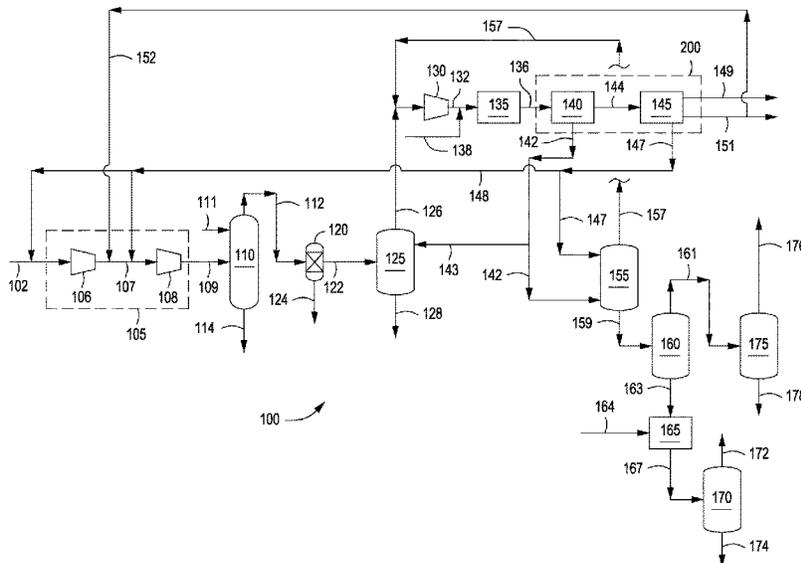
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(57) **ABSTRACT**

Systems and methods for separating one or more olefins are provided. In one or more embodiments, the method for separating one or more olefins can include separating at least a portion of one or more C₃ and heavier hydrocarbons from a hydrocarbon containing C₁ to C₂₀ hydrocarbons to provide a first mixture that can include methane, ethane, ethylene, and/or acetylene. At least a portion of the first mixture can be hydrogenated to convert at least a portion of the acetylene to ethane and ethylene. At least a portion of the methane can be separated from the hydrogenated mixture to provide a second mixture that can include ethane and ethylene. At least a portion of the ethylene can be separated from the second mixture to provide a first product that can include at least 95 mol % ethylene and a second product that can include at least 95 mol % ethane.

19 Claims, 2 Drawing Sheets



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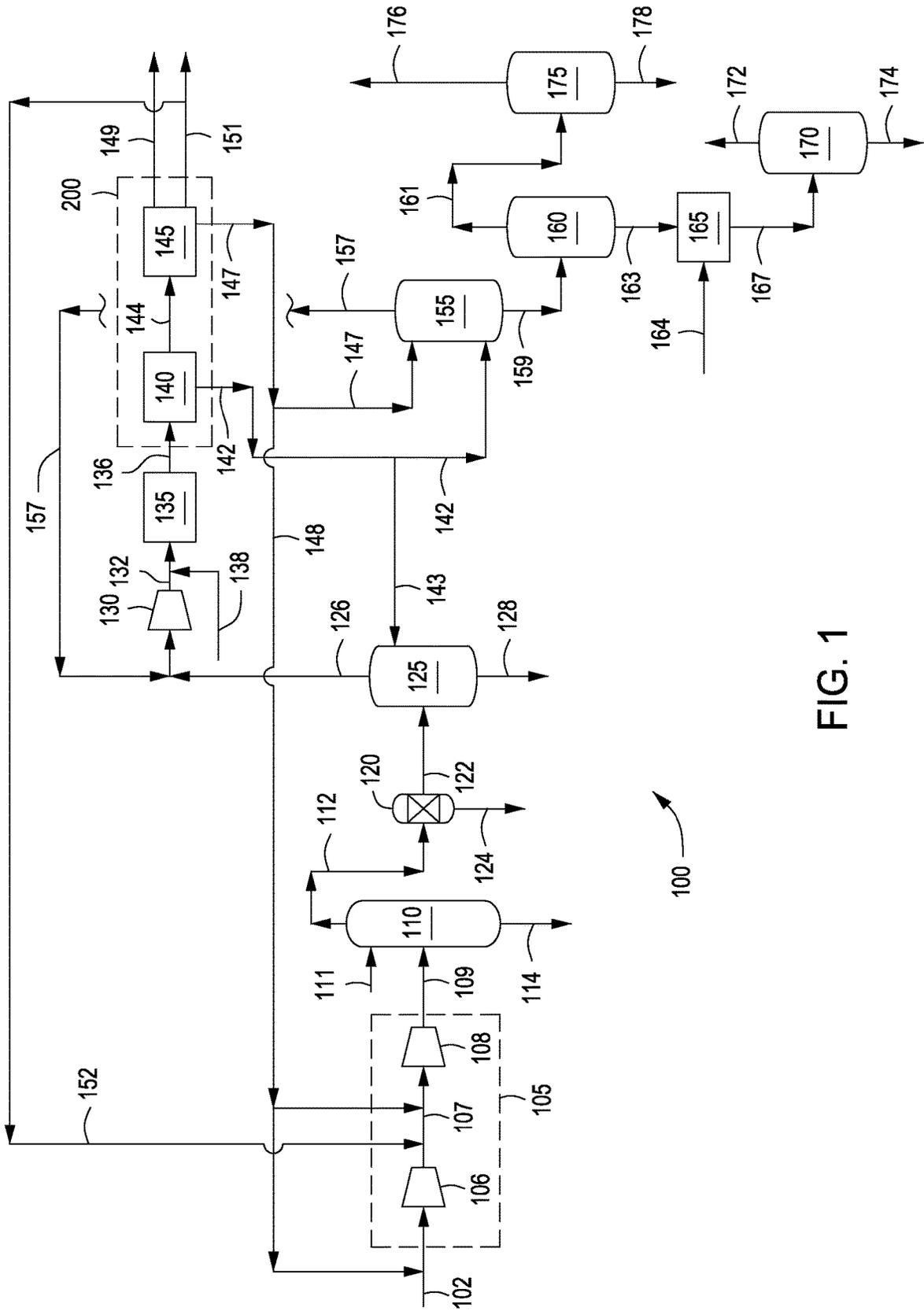


FIG. 1

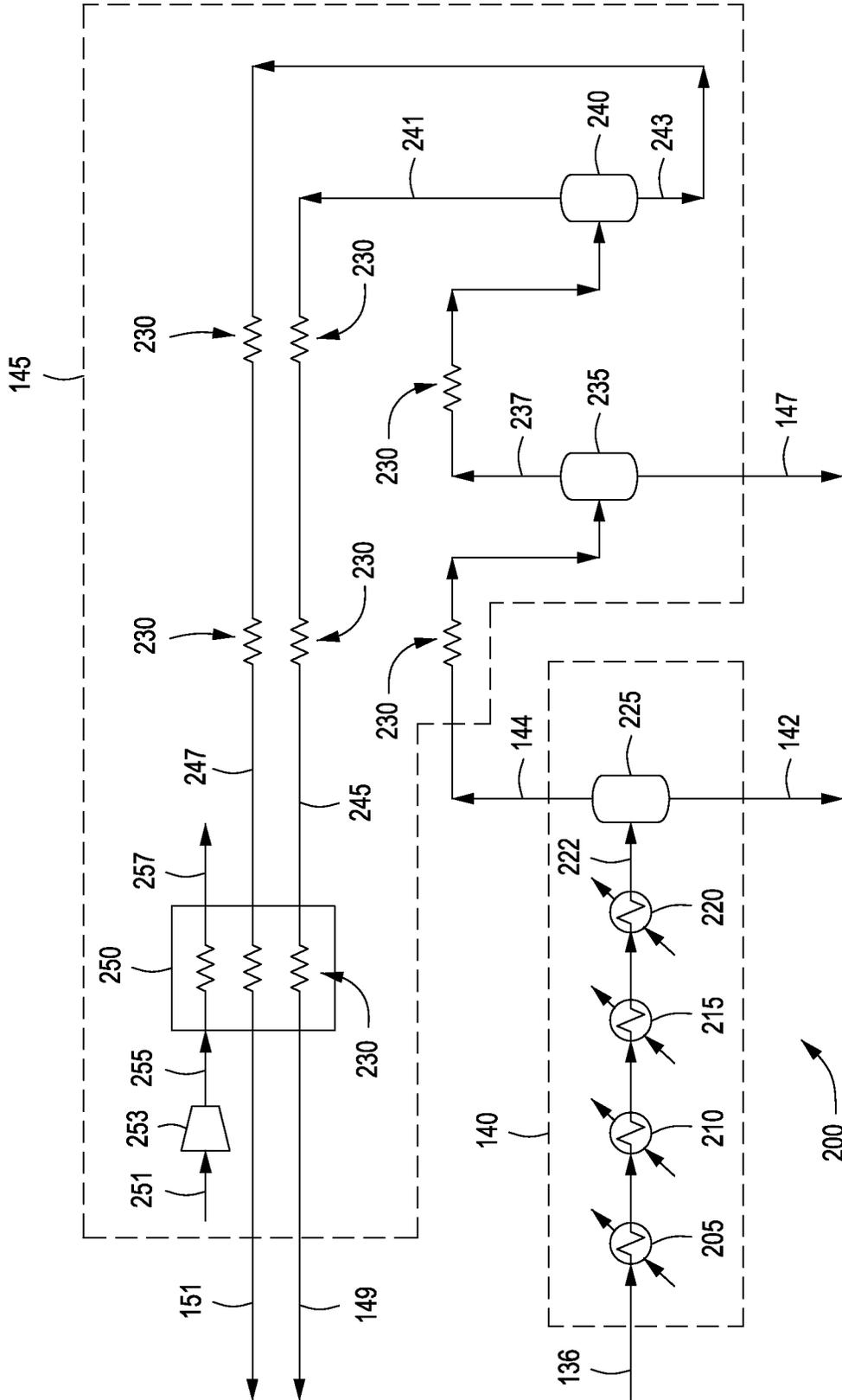


FIG. 2

METHODS AND SYSTEMS FOR SEPARATING OLEFINS

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to U.S. Provisional Patent Application having Ser. No. 61/783,970, filed Mar. 14, 2013, which is incorporated by reference herein.

BACKGROUND

Field

Embodiments described generally relate to systems and methods for separating olefinic hydrocarbons.

Description of the Related Art

Olefins are typically produced by converting a hydrocarbon feed at a high temperature to provide a hydrocarbon mixture containing various alkane, alkene, and alkyne hydrocarbons. The hydrocarbon mixture is then fractionated using a series of distillation columns, fractionation columns, compressors, and refrigeration systems to cool, condense, and separate the various hydrocarbon products. Due to the relatively low boiling points of low molecular weight hydrocarbons, ethylene and propylene are frequently employed as refrigerants while separating and fractionating the hydrocarbon mixture.

Many olefin production processes provide a hydrocarbon mixture rich in C₂-C₄ alkanes and alkenes. The C₃ and C₄ hydrocarbons can be separated from the hydrocarbon mixture, in part, due to the higher boiling points of C₃ and C₄ hydrocarbons relative to other compounds in the hydrocarbon mixture. However, the separation of the C₂ hydrocarbons into relatively pure (e.g., greater than 95 mol %) ethane and ethylene products requires the use of very low temperature (e.g., about -50° C. to about -140° C.) vapor-liquid flash and fractional distillation processes due to the relatively similar boiling points of ethylene (e.g., about -103.7° C.) and ethane (e.g., about -88.6° C.). Two or more refrigeration systems employing low temperature propylene and ethylene refrigerants are required to separate the methane, hydrogen, and ethylene from ethane. The need for dual refrigerant, low temperature, refrigeration systems requires both significant capital costs and significant operating costs. Further, the low operating temperatures and high operating pressures require the use of special metallurgies and equipment construction imposing additional capital and operating costs.

There is a need, therefore, for improved methods and systems for separating ethane and/or ethylene from a hydrocarbon mixture that in addition to ethane and/or ethylene also includes one or more additional C₁ to C₂₀ hydrocarbons.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts an illustrative system for separating hydrocarbons, according to one or more embodiments described.

FIG. 2 depicts an illustrative cooling system shown in FIG. 1, according to one or more embodiments described.

DETAILED DESCRIPTION

Methods and system for separating one or more olefins are provided. In one or more embodiments, the method for separating one or more olefins can include separating at least a portion of one or more C₃ and heavier hydrocarbons from a hydrocarbon containing C₁ to C₂₀ hydrocarbons to provide

a first hydrocarbon mixture that can include one or more of methane, ethane, ethylene, and/or acetylene (ethyne). At least a portion of the first hydrocarbon mixture can be hydrogenated to convert at least a portion of the acetylene to ethane and ethylene. At least a portion of the methane can be separated from the hydrogenated mixture to provide a second hydrocarbon mixture that can include ethane and ethylene. At least a portion of the ethylene can be separated from the second hydrocarbon mixture to provide a first product that can include at least 95 mol % ethylene and a second product that can include at least 95 mol % ethane. The ethylene can be separated from the second hydrocarbon mixture at a pressure of about 360 kPa to about 4,000 kPa or about 500 kPa to about 2,500 kPa.

FIG. 1 depicts an illustrative system **100** for separating hydrocarbons according to one or more embodiments. The system **100** can include one or more compressors (two are shown **105**, **130**), one or more scrubbers **110**, one or more driers **120**, one or more vapor-liquid separators (five are shown **125**, **155**, **160**, **170**, **175**), one or more reactor systems (two are shown **135**, **165**), and one or more chilling systems **200**. The chilling system **200** can include one or more coolers or cooling systems (two are shown **140**, **145**). One or more hydrocarbons via line **102** can be introduced to the compressor **105** to provide a compressed fluid (e.g., compressed hydrocarbon fluid having gaseous and/or liquid state) via line **109**. The hydrocarbon in line **102** can include one or more liquid hydrocarbons, gaseous hydrocarbons, fluidized hydrocarbons, or any mixture thereof. The hydrocarbon in line **102** can include, but is not limited to, one or more C₁ to C₂₀ hydrocarbons. The C₁ to C₂₀ hydrocarbons can include, but are not limited to, one or more alkanes, one or more alkenes, one or more alkynes, or any mixture thereof. The hydrocarbon in line **102** can also include one or more acid gases. Illustrative acid gases can include, but are not limited to, carbon dioxide and/or hydrogen sulfide. The hydrocarbon in line **102** can also include one or more sour gases or compounds. Illustrative sour gases or compounds can include, but are not limited to, hydrogen sulfide and organosulfur compounds, such as mercaptans. The hydrocarbon in line **102** can include, but is not limited to, hydrogen, methane, ethane, ethylene, acetylene, propane, propylene, butane, butane, pentane, pentene, isomers thereof, or any mixture thereof.

The hydrocarbon in line **102** can include hydrogen in an amount of about 0.5 mol %, about 1 mol %, about 2 mol %, about 3 mol %, about 4 mol %, or less than 5 mol % to 5 mol %, less than 10 mol %, less than 15 mol %, or less than 25 mol %. The methane concentration in the hydrocarbon in line **102** can be about 0.5 mol %, about 1 mol %, about 2 mol %, about 3 mol %, about 4 mol %, or less than 5 mol % to 5 mol %, less than 10 mol %, less than 15 mol %, or less than 25 mol %. The ethane concentration in the hydrocarbon in line **102** can be about 0.5 mol %, about 1 mol %, about 2 mol %, about 3 mol %, about 4 mol %, or less than 5 mol % to 5 mol %, less than 10 mol %, less than 15 mol %, or less than 25 mol %. The acetylene concentration in the hydrocarbon in line **102** can be about 0.1 mol %, about 0.5 mol %, about 0.75 mol %, about 1 mol %, or less than 2 mol % to 2 mol %, less than 3 mol %, less than 5 mol %, or less than 10 mol %. The propane concentration in the hydrocarbon in line **102** can be about 0.5 mol %, about 1 mol %, about 2 mol %, about 3 mol %, about 4 mol %, or less than 5 mol % to 5 mol %

%, less than 10 mol %, less than 15 mol %, or less than 25 mol %. The propylene concentration in the hydrocarbon in line **102** can be about 0.5 mol %, about 1 mol %, about 2 mol %, about 3 mol %, about 4 mol %, or less than 5 mol % to 5 mol %, less than 10 mol %, less than 15 mol %, or less than 25 mol %. The acid gas concentration in the hydrocarbon in line **102** can be about 0.01 mol %, about 0.05 mol %, about 0.1 mol %, about 0.2 mol %, about 0.3 mol %, about 0.4 mol %, or less than 0.5 mol % to 0.5 mol %, less than 0.7 mol %, less than 1 mol %, less than 1.3 mol %, or less than 1.5 mol %. The sour gas concentration in the hydrocarbon in line **102** can be about 0.01 mol %, about 0.05 mol %, about 0.1 mol %, about 0.2 mol %, about 0.3 mol %, about 0.4 mol %, or less than 0.5 mol % to 0.5 mol %, less than 0.7 mol %, less than 1 mol %, less than 1.3 mol %, or less than 1.5 mol %.

The hydrocarbon in line **102** can be at a pressure of about 100 kPa, about 300 kPa, about 500 kPa, or about 700 kPa to about 800 kPa, about 1,000 kPa, about 1,300 kPa, or about 1,500 kPa. The hydrocarbon in line **102** can be at a temperature of about 0° C., about 5° C., about 10° C., or about 15° C. to about 75° C., about 80° C., about 90° C., or about 100° C.

In one or more embodiments, one or more C₄ and heavier hydrocarbons (e.g., C₄+ hydrocarbons) can be cracked or otherwise processed in a high temperature, pyrolytic process to produce the hydrocarbon in line **102**. In other embodiments, one or more C₃ and heavier hydrocarbons from a hydrocarbon containing C₁ to C₂₀ hydrocarbons can be separated or otherwise processed to produce the hydrocarbon in line **102**. Illustrative pyrolytic processes can include, but are not limited to, fluid catalytic cracking (“FCC”), thermal cracking, hydrocracking, or any combination thereof. An illustrative advanced catalytic olefins (“ACO”) process and system suitable for producing at least a portion of the hydrocarbon in line **102** can include those discussed and described in U.S. Pat. No. 7,301,063. An illustrative methanol to olefins (“MTO”) process and system, suitable for producing at least a portion of the hydrocarbon in line **102** can include those discussed and described in U.S. Pat. Nos. 5,191,141; 4,590,320; 4,550,217; and 4,496,786. As such, at least a portion of the hydrocarbon in line **102** can be produced by cracking a heavy hydrocarbon containing C₄+ hydrocarbons in a fluid catalytic cracker, an advanced catalytic olefins process, a methanol to olefins process, a thermal cracker, a hydrocracker, or any combination thereof.

In one or more embodiments, the hydrocarbon in line **102** produced via one or more pyrolytic processes, such as the FCC, ACO, and/or MTO process, can have low concentrations of hydrogen and methane. For example, the hydrocarbon in line **102** can include less than 15 mol % hydrogen and less than 15 mol % methane. The low hydrogen and methane concentrations can permit the separation of the hydrogen and methane from the hydrocarbon at pressures greater than 1,000 kPa and temperatures greater than the boiling point of propylene (e.g., about -47.4° C.) to provide an ethylene/ethane mixture. The reduced concentration of hydrogen and methane in the ethane/ethylene mixture can permit subsequent separation of the ethylene/ethane mixture into a relatively pure ethane product, e.g., greater than 95 mol % ethane, and a relatively pure ethylene product, e.g., greater than 95 mol % ethylene, at a pressure of about 360 kPa or greater and a temperature of about -47.4° C. or greater. The power required to provide the higher separation pressure, however, increases the overall energy consumption.

As depicted in FIG. 1, the compressor **105** can include a first stage **106** that can provide a first compressed fluid (e.g.,

compressed hydrocarbon fluid having gaseous and/or liquid state) via line **107** and a second stage **108** that can provide the first compressed fluid via line **109**. In one or more embodiments, the first stage **106** and the second stage **108** can be separate, independent compressors. The one or more compressors **105** can include one or more systems, devices or combination of systems and/or devices suitable for compressing a fluid at a first pressure to provide a fluid at a second pressure, where the second pressure is greater than the first pressure. In one or more embodiments, the pressure of the compressed fluid in line **102** can be increased by about 500 kPa or greater, about 1,000 kPa or greater, about 1,500 kPa or greater, or about 2,000 kPa or greater by passage through the first stage **106** and the second stage **107**. The pressure of the compressed fluid in line **109** can be about 600 kPa, about 1,300 kPa, about 2,000 kPa, or about 2,700 kPa to about 1,700 kPa, about 2,500 kPa, about 3,000 kPa, about 3,500 kPa, or greater. In one or more embodiments, the compressor **105** can include one or more stages (two as shown **106**, **108**). In one or more embodiments, the compressor **105** can include one or more liquid and/or air cooled intercoolers between any two or more compressor stages. In one or more embodiments, shaft power can be supplied to the one or more compressors **105** via one or more electric motors, steam turbines, gas turbines, or any combination thereof.

The compressed fluid in line **109** can be introduced to the one or more scrubbers **110**, where at least a portion of any acid gases present can be converted to one or more insoluble compounds and removed from the compressed fluid. A caustic solution can be introduced or otherwise flowed into the scrubber **110** via line **111**. The caustic solution can have a pH of greater than 7, such as about 8 to about 14, or about 8.5 to about 12. In some example, the caustic solution can include an aqueous solution or mixture containing one or more of a hydroxide, a hypochlorite, ammonium, an amine, or other basic compounds. A spent caustic solution via line **114** can be recovered from the scrubber **110** for treatment, regeneration, and/or disposal and a scrubbed fluid via line **112** can be recovered from the scrubber **110**. A spent caustic solution via line **114** can be recovered from the scrubber **110** for treatment, regeneration, and/or disposal. The operating pressure of the scrubber **110** can be about 600 kPa, about 1,300 kPa, about 1,700 kPa, about 2,000 kPa, about 2,500 kPa, or about 2,700 kPa to about 3,000 kPa, about 3,500 kPa, or greater. The operating temperature of the scrubber **110** can be about 0° C., about 5° C., about 10° C., or about 15° C. to about 75° C., about 80° C., about 90° C., or about 100° C.

The scrubber **110** can include one or more systems, devices or any combination of systems and/or devices suitable for removing all or a portion of the one or more acid gases in the compressed fluid in line **109** to provide a low (or reduced) acid concentration compressed fluid via line **112** and the spent caustic solution via line **114**. The acid concentration in the compressed fluid in line **114** can be about 5 mol % or less, about 3 mol % or less, about 1 mol % or less, about 0.5 mol % or less, about 0.1 mol %, or less. The scrubber **110** can include one or more recirculation systems for recirculation of the caustic scrubbing solution through the scrubber **110**. The scrubber **110** can be a vertical column having a length over diameter (L/D) ratio greater than 1, greater than 5, or greater than 10. In one or more embodiments, all or a portion of the interior of the scrubber **110** can be filled with trays and/or packing to increase the effective mass transfer area within the scrubber **110**. In one or more

embodiments, all or a portion of the interior of the scrubber **110** can be empty, that is without trays or packing.

The scrubbed fluid in line **112** can be introduced to the drier **120**, where at least a portion of any water present in the scrubbed fluid can be removed to provide a recovered water via line **124** and an at least partially dried fluid via line **122**. The drier **120** can include one or more deliquescent driers, regenerative desiccant driers, refrigeration driers, membrane driers, or any combination thereof. The dried fluid exiting the drier via line **122** can have a dew point of about 0° C. or less, about -20° C. or less, about -40° C. or less, about -80° C. or less, about -100° C., or less. The temperature of the dried fluid in line **122** can be about 500 kPa, about 1,000 kPa, about 1,400 kPa, or about 1,800 kPa to about 1,700 kPa, about 2,500 kPa, about 3,000 kPa, about 3,500 kPa, or greater.

In one or more embodiments, the dried fluid in line **122** can be introduced to the vapor-liquid separator **125** to provide an overhead via line **126** and bottoms via line **128**. In some embodiments, the vapor-liquid separator can be a “depropanizer” and the bottoms via line **128** can include C₄ and heavier hydrocarbons and the overhead via line **126** can include C₃ and lighter hydrocarbons. In other embodiments, the vapor-liquid separator can be a “deethanizer” and the bottoms via line **128** can include one or more C₃ and heavier hydrocarbons and the overhead via line **126** can include C₁ and C₂ hydrocarbons. For simplicity and ease of description, the system **100** will be further discussed and describe in the context of **125** as a depropanizer. The operating pressure of the depropanizer **125** can be about 500 kPa, about 1,000 kPa, about 1,400 kPa, about 1,500 kPa, or about 1,600 kPa to about 1,700 kPa, about 1,800 kPa, about 2,500 kPa, about 3,000 kPa, about 3,500 kPa, or greater. The operating temperature of the depropanizer **125** can be about -73° C., about -65° C., about -60° C., about -55° C., about -53° C., about -50° C., about -48° C., about -45° C., about -43° C., about -40° C., about -38° C., about -35° C., about -33° C., about -30° C., about -27° C., about -25° C., or about -23° C. to about -20° C., about -17° C., about -15° C., about -13° C., about -10° C., about -8° C., about -5° C., about -3° C., about 0° C., about 5° C., about 10° C., about 12° C., about 15° C., or about 17° C.

In some embodiments, the C₄ and heavier hydrocarbons via line **128** can include, but are not limited to, butane, butene, butylene, pentane, pentene, isomers thereof, unsaturated derivatives thereof, or any mixture thereof. In an alternative embodiment, the C₃ and heavier hydrocarbons via line **128** can include, but are not limited to, propane, propylene, butane, butene, butylene, pentane, pentene, isomers thereof, unsaturated derivatives thereof, or any mixture thereof. In one or more embodiments, all or a portion of the C₃ and heavier hydrocarbons or the C₄ and heavier hydrocarbons in line **128** can be recycled to a pyrolytic or other process used to produce at least a portion of the hydrocarbon in line **102**. The pressure of the C₃ and heavier hydrocarbons or the C₄ and heavier hydrocarbons in line **128** can be about 300 kPa, about 500 kPa, about 600 kPa, or about 700 kPa to about 1,700 kPa, about 2,100 kPa, about 2,500 kPa, about 3,000 kPa, or greater. The temperature of the C₃ and heavier hydrocarbons or the C₄ and heavier hydrocarbons in line **128** can be about -60° C., about -50° C., or about -40° C., to about 0° C., about 10° C., about 20° C., or about 30° C.

In one or more embodiments, the depropanizer **125** can include one or more systems, devices, or any combination of systems and/or devices suitable for selectively separating C₃ and lighter hydrocarbons from a mixture containing one or more C₁ to C₂₀ hydrocarbons. The depropanizer **125** can be

a vertical column having a length over diameter (L/D) ratio greater than 1, greater than 5, or greater than 10 in some embodiments. All or a portion of the interior of the depropanizer **125** can be filled with trays and/or packing to increase the effective mass transfer area within the depropanizer **125**. All or a portion of the interior of the depropanizer **125** can be empty, that is without trays or packing. One or more condensers can be located internal or external to the depropanizer **125**. One or more reboilers can be located internal or external to the depropanizer **125**.

The overhead in line **126** can include, but is not limited to, hydrogen, methane, ethane, ethylene, acetylene, propane, propylene, isomers thereof, or any mixture thereof. The hydrogen concentration in the overhead in line **126** can be about 0.1 mol %, about 0.5 mol %, about 1 mol %, or about 2 mol % to less than 5 mol %, less than 7 mol %, less than 10 mol %, or less than 15 mol %. The methane concentration in the overhead in line **126** can be about 0.1 mol % to less than 12 mol %, such as about 0.1 mol %, about 0.5 mol %, about 1 mol %, or about 2 mol % to about 3 mol %, about 5 mol %, about 7 mol %, or less than 12 mol %. The ethane concentration in the overhead in line **126** can be about 0.5 mol %, about 1 mol %, about 2 mol %, about 3 mol %, about 4 mol %, or less than 5 mol % to 5 mol %, less than 10 mol %, less than 15 mol %, or less than 25 mol %. The ethylene concentration in the overhead in line **126** can be about 0.5 mol %, about 1 mol %, about 2 mol %, about 3 mol %, about 4 mol %, or less than 5 mol % to 5 mol %, less than 10 mol %, less than 15 mol %, or less than 25 mol %. The acetylene concentration in the overhead in line **126** can be about 0.1 mol %, about 0.5 mol %, about 0.75 mol %, about 1 mol %, about 1.3 mol %, about 1.5 mol %, or about 2 mol % to about 2.5 mol %, about 3 mol %, less than 5 mol %, less than 7 mol %, or less than 10 mol %. The propane concentration in the overhead in line **126** can be about 0.5 mol %, about 1 mol %, about 1.5 mol %, about 2 mol %, about 3 mol %, about 4 mol %, or about 5 mol % to about 6 mol %, about 8 mol %, less than 10 mol %, less than 15 mol %, or less than 25 mol %. The propylene concentration in the overhead in line **126** can be about 0.5 mol %, about 1 mol %, about 2 mol %, about 3 mol %, about 4 mol %, or less than 5 mol % to 5 mol %, less than 10 mol %, less than 15 mol %, or less than 25 mol %.

The overhead in line **126** can be at a pressure of about 400 kPa, about 600 kPa, about 800 kPa, or about 900 kPa to about 1,700 kPa, about 2,000 kPa, about 2,500 kPa, or about 3,000 kPa. The overhead in line **126** can be at a temperature of about -73° C., about -65° C., about -60° C., about -55° C., about -53° C., about -50° C., about -48° C., about -45° C., about -43° C., about -40° C., about -38° C., about -35° C., about -33° C., about -30° C., about -27° C., about -25° C., or about -23° C. to about -20° C., about -17° C., about -15° C., about -13° C., about -10° C., about -8° C., about -5° C., about -3° C., about 0° C., about 5° C., about 10° C., about 12° C., about 15° C., or about 17° C.

The overhead via line **126** can be introduced to the compressor **130** to provide a compressed fluid via line **132**. The pressure of the overhead in line **126** can be increased by about 1,500 kPa or greater, about 2,000 kPa or greater, about 2,500 kPa or greater, or about 3,000 kPa or greater, by passage through the one or more compressors **130**. The compressed fluid in line **132** can be at a pressure of about 1,900 kPa, about 2,100 kPa, about 2,300 kPa, or about 2,400 kPa to about 4,700 kPa, about 5,000 kPa, about 5,500 kPa, about 6,000 kPa, or greater.

The compressor **130** can include one or more systems, devices, or combination of systems and/or devices suitable

for compressing a fluid at a first pressure to provide a fluid at a second pressure, where the second pressure is greater than the first pressure. The compressor **130** can include one or more stages, two or more separate and independent compressors, or a combination thereof. The compressor **130** can include one or more intercoolers between any two or more compressors and/or compressor stages. Shaft power can be supplied to the one or more compressors **130** via one or more electric motors, steam turbines, gas turbines, or any combination thereof.

The compressed fluid via line **132** can be introduced to the reactor system (“acetylene converter”) **135**, where at least a portion of any acetylene present in the compressed fluid can be converted to ethane and/or ethylene to provide a hydrogenated mixture via line **136**. Hydrogen can be introduced via line **138** to the compressed fluid in line **132** prior to introducing the compressed fluid to the acetylene converter **135** or the hydrogen can be introduced directly to the acetylene converter **135**. The hydrogen introduced via line **138** can be about 50 mol % hydrogen or greater, about 75 mol % hydrogen or greater, about 90 mol % hydrogen or greater, about 95 mol % hydrogen or greater, about 99 mol % hydrogen or greater, or about 99.9 mol % hydrogen or greater. The hydrogen in **138** can contain carbon monoxide and/or carbon dioxide.

In one or more embodiments, about 75%, about 80%, about 90%, about 95%, about 99%, or about 99.9% of the acetylene present in the compressed process fluid in line **132** can be converted to ethane and/or ethylene in the acetylene converters **135**. The acetylene concentration in the hydrogenated mixture via line **136** can be about 1 mol % or less, about 0.5 mol % or less, about 0.1 mol % or less, about 0.05 mol % or less, about 0.03 mol % or less, about 0.01 mol % or less. The pressure of the hydrogenated mixture in line **136** can be about 1,100 kPa, about 1,300 kPa, about 1,400 kPa, about 1,500 kPa to about 4,200 kPa, about 4,400 kPa, about 4,700 kPa, about 5,200 kPa, or greater.

The one or more acetylene converters **135** can include one or more systems, devices or combination of systems and/or devices suitable for converting at least a portion of any acetylene present in the compressed process fluid in line **132** to ethane and ethylene. The one or more acetylene converters **135** can contain one or more catalyst beds. The one or more catalyst beds can be fixed beds, fluidized beds, ebullating beds, slurry beds, moving beds, bubbling beds, any other suitable type of catalyst bed, or any combination thereof. The one or more acetylene converters **135** can include one or more dual-bed converter systems such as those discussed and described in U.S. Pat. No. 7,038,097. The catalyst within the acetylene converter **135** can include, but is not limited to, one or more nickel based catalysts, such as Ni/NiAl₂O₄, one or more palladium based catalysts, such as Pd/PdAl₂O₃, alloys thereof, derivatives thereof, combinations thereof, or any mixture thereof.

The hydrogenated mixture via line **136** can be introduced to the chilling system **200** to provide a cooled hydrogenated mixture via lines **142** and/or **147**. The chilling system **200** can include a first cooler **140** and a second cooler **145**. The first cooler **140** can condense at least a portion of the hydrogenated mixture, which can be recovered via line **142**. Non-condensed hydrogenated mixture can be recovered via line **144** from the first cooler **140**, which can be introduced to the second cooler **145** to provide a condensed hydrogenated mixture via line **147** and tail gases via lines **149** and **151**. A hydrogen-rich tail gas can be recovered via line **149** and a hydrogen-lean tail gas can be recovered via line **151**. In some embodiments, the hydrogen-lean tail gas recovered

via line **151**, or any other fluid or composition, can be recycled or otherwise flowed via line **152** (e.g., a bypass line) to the compressor **105**, such as to line **107** disposed downstream of the first stage **106** and upstream of the second stage **108**, as depicted in FIG. 1. Alternatively, although not shown, the hydrogen-lean tail gas or other fluid or composition via line **152** can be recycled or otherwise flowed upstream of the first stage **106**, such as to line **102** or downstream of the second stage **108**, such as to line **109**.

The first cooler **140** and/or the second cooler **145** can cool the hydrogenated mixture introduced via line **136** using any suitable heat transfer medium or combination of heat transfer mediums. Illustrative heat transfer mediums that can be used to cool the hydrogenated mixture introduced to the first cooler **140** can include, but are not limited to, ethylene, propylene, cooling water, air, any combination thereof, or any mixture thereof. Illustrative heat transfer mediums that can be used to cool the non-condensed hydrogenated mixture introduced via line **144** to the second cooler **145** can include, but are not limited to, propylene. The first cooler **140**, the second cooler **145**, or both can use refrigerated propylene as the heat transfer medium. The use of refrigerated ethylene to cool the hydrogenated mixture is not required. In one or more embodiments, refrigerated propylene at a temperature of about 5° C., about 0° C., about -5° C., about -10° C., about -20° C., about -30° C., about -40° C., or less can be used to indirectly cool the hydrogenated mixture introduced via line **136** to the chilling system **200**.

The chilling system **200** can include any suitable system, device, or combination of systems and/or devices for cooling the hydrogenated mixture in line **136**. The chilling system **200** can include one or more heat exchangers. For example, the chilling system **200** can include, but is not limited to, one or more shell-and-tube heat exchangers, core-type heat exchangers, plate and frame heat exchangers, spiral wound heat exchangers, U-tube heat exchangers, and/or bayonet style heat exchangers. The one or more heat exchangers can include surface enhanced tubes (e.g., fins, static mixers, rifling, heat conductive packing, turbulence causing projections, or any combination thereof), and the like.

In one or more embodiments, at least a portion of the condensed hydrogenated mixture via line **142** and/or line **147** can be introduced to the vapor-liquid separator (“demethanizer”) **155** to provide a methane-rich overhead via line and methane-lean bottoms via line **159**. In one or more embodiments, at least a portion of the condensed hydrogenated mixture in line **142** can be recycled via line **143** to the depropanizer **125** as a reflux. In one or more embodiments, at least a portion of the condensed hydrogenated mixture in line **147** can be recycled via line **148** to the compressor **105**. As illustrated, a portion of the hydrogenated mixture in line **147** can be recycled via line **148** to the first stage **106** and/or a portion can be recycled to the second stage **108**.

In one or more embodiments, at least a portion of the methane-rich overhead via line **157** can be recycled to the compressor **130**. In one or more embodiments, all or a portion of the methane-rich overhead via line **157** can be recovered as a product, which can be further processed or used as fuel, for example.

The operating pressure of the demethanizer **155** can be about 600 kPa, about 700 kPa, about 800 kPa, or about 900 kPa to about 2,500 kPa, about 2,700 kPa, about 2,900 kPa, about 3,500 kPa, about 4,000 kPa, or about 4,200 kPa. The operating temperature of the demethanizer **155** can be greater than the boiling point of propylene (e.g., about

–48.1° C.). The operating temperature of the demethanizer **155** can be about –48° C., about –45° C., about –43° C., about –40° C., about –38° C., about –35° C., about –33° C., about –30° C., about –27° C., about –25° C., about –23° C., about –20° C., about –17° C., about –15° C., or about –13° C. to about –10° C., about –7° C., about –5° C., about –3° C., about 0° C., about 5° C., about 10° C., about 12° C., about 15° C., or about 17° C.

The demethanizer **155** can include one or more systems, devices, or any combination of systems and/or devices suitable for providing the methane-rich overhead via line **157** and the methane-lean bottoms via line **159**. The demethanizer **155** can be a vertical column having a length over diameter (L/D) ratio greater than 1, greater than 5, or greater than 10. All or a portion of the interior of the demethanizer **155** can be filled with trays and/or packing to increase the effective mass transfer area within the demethanizer **155**. All or a portion of the interior of the demethanizer **155** can be empty, that is without trays or packing. One or more condensers can be located internal or external to the demethanizer **155**. One or more reboilers can be located internal or external to the demethanizer **155**.

The methane-lean bottoms via line **159** can be introduced to the vapor-liquid separator (“deethanizer”) **160** to provide a C₂-rich overhead via line **161** and a C₂-lean bottoms via line **163**. The operating pressure of the deethanizer **160** can be about 400 kPa, about 600 kPa, about 800 kPa, about 900 kPa, about 1,000 kPa, about 1,200 kPa, or about 1,400 kPa to about 1,700 kPa, about 2,000 kPa, about 2,500 kPa, about 3,000 kPa, about 3,500 kPa, or about 4,000 kPa. The operating temperature of the deethanizer **160** can be about –73° C., about –65° C., about –60° C., about –55° C., about –53° C., about –50° C., about –48° C., about –45° C., about –43° C., about –40° C., about –38° C., about –35° C., about –33° C., about –30° C., about –27° C., about –25° C., or about –23° C. to about –20° C., about –17° C., about –15° C., about –13° C., about –10° C., about –8° C., about –5° C., about –3° C., about 0° C., about 5° C., about 10° C., about 12° C., about 15° C., or about 17° C.

The ethane concentration in the C₂-rich overhead in line **161** can be about 3 mol %, about 9 mol %, about 18 mol %, or about 35 mol % to about 40 mol %, about 47 mol %, about 55 mol %, about 70 mol %, about 85 mol %, or about 97 mol %. The ethylene concentration in the C₂-rich overhead in line **161** can be about 3 mol %, about 9 mol %, about 18 mol %, or about 35 mol % to about 40 mol %, about 47 mol %, about 55 mol %, about 70 mol %, about 85 mol %, or about 97 mol %. The pressure of the C₂-rich overhead in line **161** can be about 400 kPa, about 500 kPa, about 600 kPa, or about 700 kPa to about 3,500 kPa, about 3,800 kPa, about 4,500 kPa, or about 4,800 kPa. The temperature of the C₂-rich overhead in line **161** can be about –83° C., about –80° C., about –77° C., about –75° C., about –73° C., about –65° C., about –60° C., about –55° C., about –53° C., about –50° C., about –48° C., about –45° C., about –43° C., about –40° C., about –38° C., about –35° C., about –33° C., about –30° C., about –27° C., about –25° C., or about –23° C. to about –20° C., about –17° C., about –15° C., about –13° C., about –10° C., about –8° C., about –5° C., about –3° C., about 0° C., about 5° C., about 10° C., about 12° C., about 15° C., or about 17° C.

The C₂-lean bottoms in line **163** can include, but is not limited to, propane, propylene, methylacetylene (propyne), and/or propadiene. The propane concentration in the C₂-lean bottoms in line **163** can be about 5 mol %, about 10 mol %, about 20 mol %, or about 40 mol % to about 50 mol %, about 60 mol %, about 80 mol %, or about 95 mol %. The

propylene concentration in the C₂-lean bottoms in line **163** can be about 5 mol %, about 10 mol %, about 20 mol %, or about 40 mol % to about 50 mol %, about 60 mol %, about 80 mol %, or about 95 mol %. The methylacetylene concentration in the C₂-lean bottoms in line **163** can be about 0.1 mol %, about 0.3 mol %, about 0.5 mol %, or about 0.7 mol % to about 1.5 mol %, about 1.7 mol %, about 2 mol %, or about 2.5 mol %. The propadiene concentration in the C₂-lean bottoms in line **163** can be about 1 mol %, about 1.5 mol %, about 2 mol %, or about 2.5 mol % to about 4 mol %, about 4.5 mol %, about 5 mol %, or about 6 mol %.

The deethanizer **160** can include one or more systems, devices, or any combination of systems and/or devices suitable for providing the C₂-rich overhead via line **161** and the C₂-lean bottoms via line **163**. In some examples, the deethanizer **160** can provide the C₂-rich overhead via line **161** and the C₂-lean bottoms via line **163**. The deethanizer **160** can include a vertical column having a length over diameter (L/D) ratio greater than 1, greater than 5, or greater than 10. All or a portion of the interior of the deethanizer can be filled with trays and/or packing to increase the effective mass transfer area within the deethanizer. All or a portion of the interior of the deethanizer can be empty that is without trays or packing. One or more condensers can be located internal or external to the deethanizer. One or more reboilers can be located internal or external to the deethanizer.

The C₂-rich overhead via line **161** can be introduced to the vapor-liquid separator (“C₂ splitter”) **175** to provide an ethylene-rich overhead (“first product”) via line **176** and an ethane-rich bottoms (“second product”) via line **178**. The operating pressure within the C₂-splitter **175** can be about 360 kPa, about 400 kPa, about 600 kPa, about 800 kPa, about 1,000 kPa, about 1,200 kPa, about 1,400 kPa, about 1,600 kPa, about 1,800 kPa, about 2,000 kPa, or about 2,200 kPa to about 2,500 kPa, about 2,700 kPa, about 3,000 kPa, about 3,300 kPa, about 3,500 kPa, about 3,700 kPa, or about 4,000 kPa. For example, the pressure within the C₂-splitter **175** can be about 360 kPa to about 4,000 kPa, about 500 kPa to about 3,500 kPa, about 900 kPa to about 3,000 kPa, or about 1,300 kPa to about 2,600 kPa.

In one or more embodiments, the first product or ethylene can be separated from the second hydrocarbon mixture at a pressure of about 360 kPa, about 400 kPa, about 450 kPa, about 500 kPa, about 550 kPa, about 600 kPa, about 700 kPa, about 750 kPa, about 800 kPa, about 850 kPa, about 900 kPa, about 950 kPa, about 1,000 kPa, about 1,050 kPa, about 1,100 kPa, about 1,150 kPa, about 1,200 kPa, about 1,250 kPa, about 1,300 kPa, about 1,350 kPa, about 1,400 kPa, about 1,450 kPa, or about 1,500 kPa to about 2,000 kPa, about 2,100 kPa, about 2,200 kPa, about 2,300 kPa, about 2,400 kPa, about 2,500 kPa, about 2,600 kPa, about 2,700 kPa, about 2,800 kPa, about 2,900 kPa, about 3,000 kPa, about 3,100 kPa, about 3,200 kPa, about 3,300 kPa, about 3,400 kPa, about 3,500 kPa, about 3,600 kPa, about 3,700 kPa, about 3,800 kPa, about 3,900 kPa, or about 4,000 kPa. In one or more embodiments, the first product or ethylene can be separated from the second hydrocarbon mixture at a pressure of at least 360 kPa, at least 400 kPa, at least 450 kPa, at least 500 kPa, at least 550 kPa, at least 600 kPa, at least 700 kPa, at least 750 kPa, at least 800 kPa, at least 850 kPa, at least 900 kPa, at least 950 kPa, at least 1,000 kPa, at least 1,050 kPa, at least 1,100 kPa, at least 1,150 kPa, at least 1,200 kPa, at least 1,250 kPa, at least 1,300 kPa, at least 1,350 kPa, at least 1,400 kPa, at least 1,450 kPa, or at least 1,500 kPa, to less than 2,000 kPa, less than 2,100 kPa, less than 2,200 kPa, less than 2,300 kPa, less than 2,400 kPa, less than 2,500 kPa, less than 2,600 kPa, less than 2,700 kPa, less

than 2,800 kPa, less than 2,900 kPa, less than 3,000 kPa, less than 3,100 kPa, less than 3,200 kPa, less than 3,300 kPa, less than 3,400 kPa, less than 3,500 kPa, less than 3,600 kPa, less than 3,700 kPa, less than 3,800 kPa, less than 3,900 kPa, or less than 4,000 kPa.

The operating temperature of the C₂-splitter **175** can be greater than the boiling point of propylene (e.g., about -48.1° C.). In one or more embodiments, the first product or ethylene can be separated from the second hydrocarbon mixture at a temperature of about -48° C., about -47° C., about -46° C., about -45° C., about -44° C., about -43° C., about -42° C., about -41° C., about -40° C., about -39° C., about -38° C., about -37° C., about -36° C., about -35° C., about -34° C., about -33° C., about -32° C., about -31° C., about -30° C., about -29° C., about -28° C., about -27° C., about -26° C., about -25° C., about -24° C., about -23° C., about -22° C., about -21° C., about -20° C., about -19° C., about -18° C., about -17° C., about -16° C., about -15° C., about -14° C., or about -13° C. to about -10° C., about -7° C., about -5° C., about -3° C., about 0° C., about 3° C., about 5° C., about 7° C., about 10° C., about 12° C., about 14° C., or about 17° C. In one or more embodiments, the first product or ethylene can be separated from the second hydrocarbon mixture at a temperature of greater than -48° C., greater than -45° C., greater than -43° C., greater than -41° C., greater than -38° C., greater than -35° C., greater than -33° C., greater than -30° C., greater than -27° C., greater than -25° C., greater than -23° C., greater than -20° C., greater than -17° C., greater than -15° C., or greater than -13° C. to less than -10° C., less than -7° C., less than -5° C., less than -3° C., less than 0° C., less than 3° C., less than 5° C., less than 7° C., less than 10° C., less than 12° C., less than 14° C., or less than 17° C.

The ethylene concentration of the first product in line **176** can be greater than 85 mol %, greater than 87 mol %, greater than 90 mol %, greater than 92 mol %, greater than 93 mol %, greater than 94 mol %, greater than 95 mol %, greater than 96 mol %, greater than 97 mol %, greater than 98 mol %, greater than 98.5 mol %, greater than 99 mol %, greater than 99.5 mol %, or greater than 99.9 mol %. The pressure of the first product in line **176** can be about 400 kPa, about 500 kPa, about 600 kPa, or about 700 kPa to about 2,500 kPa, about 2,700 kPa, about 3,300 kPa, or about 4,000 kPa. The temperature of the first product in line **176** can be about -48° C., about -45° C., about -43° C., about -40° C., about -38° C., about -35° C., about -33° C., about -30° C., about -27° C., about -25° C., about -23° C., about -20° C., about -17° C., about -15° C., or about -13° C. to about -10° C., about -7° C., about -5° C., about -3° C., about 0° C., about 3° C., about 5° C., about 7° C., about 10° C., about 13° C., about 15° C., or about 17° C.

The ethane concentration in the second product in line **178** can be greater than 85 mol %, greater than 87 mol %, greater than 90 mol %, greater than 92 mol %, greater than 93 mol %, greater than 94 mol %, greater than 95 mol %, greater than 96 mol %, greater than 97 mol %, greater than 98 mol %, greater than 98.5 mol %, greater than 99 mol %, greater than 99.5 mol %, or greater than 99.9 mol %. The pressure of the second product in line **178** can be about 400 kPa, about 500 kPa, about 600 kPa, or about 700 kPa to about 2,500 kPa, about 2,700 kPa, about 3,300 kPa, or about 4,000 kPa. The temperature of the second product in line **178** can be about -48° C., about -45° C., about -43° C., about -40° C., about -38° C., about -35° C., about -33° C., about -30° C., about -27° C., about -25° C., about -23° C., about -20° C., about -17° C., about -15° C., or about -13° C. to about -10° C., about -7° C., about -5° C., about -3° C.,

about 0° C., about 3° C., about 5° C., about 7° C., about 10° C., about 13° C., about 15° C., or about 17° C.

The one or more C₂-splitters **175** can include one or more systems, devices, or any combination of systems and/or devices suitable for providing an overhead containing ethylene and a bottoms containing ethane. The C₂-splitter **190** can be a vertical column having a length over diameter (L/D) ratio greater than 1, greater than 5, or greater than 10. All or a portion of the interior of the C₂-splitter **190** can be filled with trays and/or packing to increase the effective mass transfer area within the C₂-splitter **190**. All or a portion of the interior of the C₂-splitter **190** can be empty, that is without trays or packing. One or more condensers can be located internal or external to the C₂-splitter **190**. One or more reboilers can be located internal or external to the C₂-splitter **190**.

In one or more embodiments, all or a portion of the second product in line **178** can be recycled to the pyrolytic process used to provide all or a portion of the hydrocarbon in line **102**. For example, about 5% or more, about 25% or more, about 50% or more, about 75% or more, about 85% or more, about 90% or more, about 95% or more, about 99% or more, or about 99.9% or more of the second product in line **178** can be recycled to the pyrolytic process used to provide all or a portion of the hydrocarbon in line **102**.

In one or more embodiments, the C₂-lean bottoms in line **163** can be introduced to the reactor system ("MAPD converter") **165** to provide a C₂-lean bottoms via line **167** having a reduced concentration of methylacetylene and/or propadiene. Hydrogen via line **164** can be introduced to the MAPD converter **165**. The methylacetylene and/or the propadiene present in the C₂-lean bottoms introduced via line **163** to the MAPD converter **165** can be converted to propylene. The hydrogen added via line **138** can be about 50 mol % hydrogen or greater, about 75 mol % hydrogen or greater, about 90 mol % hydrogen or greater, about 95 mol % hydrogen or greater, about 99 mol % hydrogen or greater, or about 99.9 mol % hydrogen or greater. The hydrogen added via line **138** can contain carbon monoxide and/or carbon dioxide.

In one or more embodiments, about 75%, about 80%, about 90%, about 95%, about 99%, or about 99.9% of the methylacetylene and/or propadiene present in the C₂-lean bottoms in line **163** can be converted to propylene in the MAPD converter **165**. The methylacetylene concentration in the hydrogenated mixture via line **167** can be about 1 mol % or less, about 0.5 mol %, about 0.1 mol %, about 0.05 mol %, about 0.03 mol %, about 0.01 mol %, or less. The propadiene concentration in the hydrogenated mixture via line **167** can be about 1 mol % or less, about 0.5 mol %, about 0.1 mol %, about 0.05 mol %, about 0.03 mol %, or less.

The MAPD converter **165** can include one or more systems, devices or combination of systems and/or devices suitable for converting at least a portion of any methylacetylene and/or propadiene present in the C₂-lean bottoms in line **163** to propylene. In one or more embodiments, the MAPD converter **165** can contain one or more catalyst beds. In one or more embodiments, the one or more catalyst beds can be fixed beds, fluidized beds, ebullating beds, slurry beds, moving beds, bubbling beds, any other suitable type of catalyst bed, or combinations thereof. In one or more embodiments, the catalyst within the MAPD converter **165** can include, but is not limited to, one or more palladium-based catalysts, such as available catalyst vendors such as Axens, CRI Catalyst Company, or Sud-Chemie, or any mixture thereof.

The C₂-lean bottoms via line 167 having a reduced concentration of methylacetylene and/or propadiene can be introduced to the vapor-liquid separator (“C₃ splitter”) 170 to provide a propylene-rich overhead (“third product”) via line 172 and a propane-rich bottoms (“fourth product”) via line 174. Although not shown, in one or more embodiments, all or a portion of the fourth product in line 174 can be recycled to the pyrolytic process used to provide all or a portion of the hydrocarbon in line 102. In one or more embodiments, about 5% or more, about 25% or more, about 50% or more, about 75% or more, about 85% or more, about 90% or more, about 95% or more, about 99% or more, or about 99.9% or more of the fourth product in line 174 can be recycled to the pyrolytic process used to provide all or a portion of the hydrocarbon in line 102.

FIG. 2 depicts the illustrative chilling system 200 shown in FIG. 1, according to one or more embodiments. The chilling system 200 can include the first cooler 140 and the second cooler 145, as discussed and described above with reference to FIG. 1. In one or more embodiments, the first cooler 140 can include one or more heat exchangers (four are shown 205, 210, 215, 220) and one or more vapor/liquid separators “knock-out drums” 225. In one or more embodiments, the second cooler 145 can include one or more heat exchangers 230 (nine are shown), one or more knock-out drums (two are shown 235, 240), and one or more multi-pass heat exchanger known typical in the industry as a coldbox 250. The heat exchangers 205, 210, 215, and 220 can be shell-and-tube heat exchangers and the heat exchangers 230 can be core-type heat exchangers. The multi-pass heat exchanger or the coldbox 250 can be or include one or more heat exchangers configured to cool and/or heat one or more streams using brazed aluminum heat transfer cores at least partially contained within an insulated box. For example, as shown the cold box 250 can include three heat exchangers 230.

The hydrogenated mixture via line 136 can be serially introduced to the heat exchangers 205, 210, 215, and 220 to provide an at least partially condensed hydrogenated mixture via line 222. Although not shown, the hydrogenated mixture via line 136 can be introduced in parallel, in series/parallel, and/or in parallel/series to two or more heat exchangers to provide the at least partially condensed hydrogenated mixture via line 222.

The at least partially condensed hydrogenated mixture via line 222 can be introduced to the knock-out drum 225 to provide the cooled hydrogenated mixture via line 142 and the gaseous hydrogenated mixture via line 144. The gaseous hydrogenated mixture via line 144 can be introduced to one or more of the heat exchangers 230 (one as shown) and the knock-out drum 235 to provide the condensed hydrogenated mixture via line 147 and a tail gas via line 237. The tail gas via line 237 can be introduced to one or more of the heat exchangers 230 (one as shown) and the knock-out drum 240 to provide a hydrogen-rich tail gas via line 241 and a hydrogen-lean tail gas via line 243.

In one or more embodiments, the hydrogen-rich tail gas via line 241 can be introduced through one or more heat exchangers 230 (two as shown) to provide a heated hydrogen-rich tail gas via line 245. In one or more embodiments, the hydrogen-lean tail gas via line 243 can be introduced through one or more heat exchangers 230 (two as shown) to provide a heated hydrogen-lean tail gas via line 247. The hydrogen-rich tail gas via line 245 and the hydrogen-lean tail gas via line 247 can be introduced to the coldbox 250 to provide the hydrogen-rich tail gas via line 149 and the hydrogen-lean tail gas via line 151, as shown in FIG. 1.

In one or more embodiments, propylene via line 251 can be introduced to one or more compressors 253 to provide a compressed propylene via line 255. In one or more embodiments, the pressure of the propylene in line 251 can be increased by about 1,500 kPa or greater, about 2,000 kPa or greater, about 2,500 kPa or greater, or about 3,000 kPa or greater by passage through the one or more compressors 253. The compressed propylene in line 255 can be at a temperature of about 40° C., about 45° C., about 50° C., or about 55° C. to about 80° C., about 85° C., about 90° C., or about 95° C. Although not shown, in one or more embodiments, the compressed propylene from the compressor 253 can be cooled via indirect heat exchange to provide the compressed propylene via line 255.

The compressor 253 can include one or more systems, devices, or combination of systems and/or devices suitable for compressing a fluid at a first pressure to provide a fluid at a second pressure, where the second pressure is greater than the first pressure. The compressor 253 can include one or more stages, two or more separate and independent compressors, or a combination thereof. The compressor 253 can include one or more intercoolers between any two or more compressors and/or compressor stages. Shaft power can be supplied to the one or more compressors 253 via one or more electric motors, steam turbines, gas turbines, or any combination thereof.

In one or more embodiments, propylene via line 255 can be introduced to the coldbox 250, where heat can be indirectly transferred from the propylene to the hydrogen-rich tail gas and/or the hydrogen-lean tail gas introduced via lines 245 and 247, respectively. The cooled propylene via line 257 can be recovered from the coldbox 250.

In one or more embodiments, at least a portion of the hydrogen-lean tail gas via line 151 can be recycled to the compressor 105. For example, at least a portion of the hydrogen-lean tail gas via line 151 can be recycled to the second stage 108 of the compressor 105. In one or more embodiments, the hydrogen-rich tail gas via line 149 can be recovered from the chilling system 200 as a product. In one or more embodiments, the hydrogen-rich tail gas via line 151 can be introduced to the one or more reactor systems 135 and/or 165 via lines 138 and 164, respectively.

Embodiments of the present disclosure further relate to any one or more of the following paragraphs:

1. A method for separating one or more olefins comprising: separating at least a portion of one or more C₃ and heavier hydrocarbons from a hydrocarbon comprising C₁ to C₂₀ hydrocarbons to provide a first hydrocarbon mixture comprising methane, ethane, ethylene, and acetylene; hydrogenating at least a portion of the first hydrocarbon mixture to convert at least a portion of the acetylene to ethane and ethylene; separating at least a portion of the methane from the hydrogenated mixture to provide a second hydrocarbon mixture comprising ethane and ethylene; and separating at least a portion of the ethylene from the second hydrocarbon mixture to provide a first product comprising at least 95 mol % ethylene and a second product comprising at least 95 mol % ethane, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of about 360 kPa to about 4,000 kPa.

2. The method according to paragraph 1, further comprising transferring at least a portion of the second product to a pyrolysis furnace.

3. The method according to paragraph 1 or 2, wherein the one or more C₃ and heavier hydrocarbons are separated from the hydrocarbon comprising C₁ to C₂₀ hydrocarbons at a pressure of about 400 kPa to about 3,000 kPa.

15

4. The method according to any one of paragraphs 1 to 3, wherein the methane is separated from the hydrogenated mixture at a pressure of about 600 kPa to about 4,200 kPa, and the ethylene is separated from the second hydrocarbon mixture at a pressure of about 500 kPa to about 2,500 kPa.

The method according to any one of paragraphs 1 to 4, wherein at least a portion of the hydrocarbon comprising C_1 to C_{20} hydrocarbons is produced by cracking a heavy hydrocarbon containing C_4+ hydrocarbons in a fluid catalytic cracker, a pyrolytic process, or combination thereof.

6. The method according to any one of paragraphs 1 to 5, wherein the one or more C_3 and heavier hydrocarbons are separated from the hydrocarbon comprising C_1 to C_{20} hydrocarbons at a pressure of about 800 kPa to about 2,000 kPa, the methane is separated from the hydrogenated mixture at a pressure of about 900 kPa to about 3,500 kPa, and the ethylene is separated from the second hydrocarbon mixture at a pressure of about 500 kPa to about 2,500 kPa.

7. The method according to any one of paragraphs 1 to 6, wherein the first hydrocarbon mixture is hydrogenated in the presence of a catalyst.

8. The method according to any one of paragraphs 1 to 7, wherein the methane concentration in the hydrocarbon comprising C_1 to C_{20} hydrocarbons is less than 12 mol %.

9. A method for separating one or more olefins comprising: compressing a gas comprising one or more C_1 - C_{20} hydrocarbons, water, one or more acid gases, and hydrogen; scrubbing at least a portion of the compressed fluid to remove at least a portion of the one or more acid gases; separating at least a portion of the water from the compressed fluid to provide a dehydrated fluid containing less than 0.5 mol % water, wherein the dehydrated fluid comprises the one or more C_1 - C_{20} hydrocarbons; separating at least a portion of one or more C_4 and heavier hydrocarbons from the dehydrated fluid to provide a hydrocarbon comprising one or more C_1 - C_3 hydrocarbons; separating at least a portion of one or more C_3 hydrocarbons from the hydrocarbon comprising one or more C_1 - C_3 hydrocarbons to provide a first hydrocarbon mixture comprising ethane, ethylene, acetylene, and methane; hydrogenating at least a portion of the first hydrocarbon mixture to convert at least a portion of the acetylene to ethane and ethylene; separating at least a portion of the methane from the hydrogenated mixture to provide a second hydrocarbon mixture comprising ethane and ethylene; and separating at least a portion of the ethylene from the second hydrocarbon mixture to provide a first product comprising at least 95 mol % ethylene and a second product comprising at least 95 mol % ethane, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of about 360 kPa to about 4,000 kPa.

10. The method according to paragraph 9, further comprising transferring all or a portion of the second product to a pyrolysis furnace.

11. The method according to paragraph 9 or 10, wherein the gas has a methane concentration of less than 15 mol %.

12. The method according to any one of paragraphs 9 to 11, wherein the gas has a hydrogen concentration of less than 15 mol %.

13. The method according to any one of paragraphs 9 to 12, wherein the one or more C_4 and heavier hydrocarbons are separated from the dehydrated fluid at a pressure of about 500 kPa to about 3,500 kPa.

14. The method according to any one of paragraphs 9 to 13, wherein the one or more C_3 hydrocarbons are separated from the hydrocarbon comprising one or more C_1 - C_3 hydrocarbons at a pressure of about 400 kPa to about 3,000 kPa.

16

15. The method according to any one of paragraphs 9 to 14, wherein at least a portion of the hydrocarbon comprising one or more C_1 - C_3 hydrocarbons is produced by cracking a heavy hydrocarbon containing C_4+ hydrocarbons in a fluid catalytic cracker, a pyrolytic process, or a combination thereof.

16. The method according to any one of paragraphs 9 to 15, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of about 500 kPa to about 2,500 kPa.

17. The method according to any one of paragraphs 9 to 16, wherein the one or more C_3 and heavier hydrocarbons are separated from the hydrocarbon comprising C_1 to C_{20} hydrocarbons at a pressure of about 800 kPa to about 2,000 kPa, the methane is separated from the hydrogenated mixture at a pressure of about 900 kPa to about 3,500 kPa, and the ethylene is separated from the second hydrocarbon mixture at a pressure of about 500 kPa to about 2,500 kPa.

18. A system for producing one or more olefins comprising: one or more first separators for separating at least a portion of one or more C_3 and heavier hydrocarbons from a hydrocarbon comprising C_1 to C_{20} hydrocarbons to provide a first hydrocarbon mixture comprising ethane, ethylene, and acetylene; one or more hydrogenators for hydrogenating at least a portion of the first hydrocarbon mixture to convert at least a portion of the acetylene to ethane and ethylene; one or more second separators for separating at least a portion of the methane from the hydrogenated mixture to provide a second hydrocarbon mixture comprising ethane and ethylene; and one or more third separators for separating at least a portion of the ethylene from the second hydrocarbon mixture at a pressure of about 360 kPa to about 4,000 kPa to provide a first product comprising at least 95 mol % ethylene and a second product comprising at least 95 mol % ethane.

19. The system according to paragraph 18, further comprising a recycle line for transferring at least a portion of the second product to a pyrolysis furnace.

20. The system according to paragraph 18 or 19, wherein the methane concentration of the hydrocarbon comprising C_1 to C_{20} hydrocarbons is less than 12 mol %.

21. A system for producing one or more olefins comprising: means for separating at least a portion of one or more C_3 and heavier hydrocarbons from a hydrocarbon comprising C_1 to C_{20} hydrocarbons to provide a first hydrocarbon mixture comprising ethane, ethylene, and acetylene; means for hydrogenating at least a portion of the first hydrocarbon mixture to convert at least a portion of the acetylene to ethane and ethylene; means for separating at least a portion of the methane from the hydrogenated mixture to provide a second hydrocarbon mixture comprising ethane and ethylene; and means for separating at least a portion of the ethylene from the second hydrocarbon mixture at a pressure of about 360 kPa to about 4,000 kPa to provide a first product comprising at least 95% mol ethylene and a second product comprising at least 95% mol ethane.

22. The system according to paragraph 21, further comprising a means for transferring all or a portion of the second product to a pyrolysis furnace.

23. The system according to paragraph 22, wherein the methane concentration of the hydrocarbon comprising C_1 to C_{20} hydrocarbons is less than 12% mol.

24. The method or system according to any one of paragraphs 1 to 23, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of about 400 kPa to about 4,000 kPa.

25. The method or system according to any one of paragraphs 1 to 24, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of about 600 kPa to about 4,000 kPa.

26. The method or system according to any one of paragraphs 1 to 25, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of about 800 kPa to about 4,000 kPa.

27. The method or system according to any one of paragraphs 1 to 26, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of about 1,000 kPa to about 4,000 kPa.

The method or system according to any one of paragraphs 1 to 27, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of about 1,400 kPa to about 4,000 kPa.

29. The method or system according to any one of paragraphs 1 to 28, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of about 1,600 kPa to about 4,000 kPa.

30. The method or system according to any one of paragraphs 1 to 29, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of at least 400 kPa and less than 4,000 kPa.

31. The method or system according to any one of paragraphs 1 to 30, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of at least 600 kPa and less than 4,000 kPa.

32. The method or system according to any one of paragraphs 1 to 31, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of at least 800 kPa and less than 4,000 kPa.

33. The method or system according to any one of paragraphs 1 to 32, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of at least 1,000 kPa and less than 4,000 kPa.

34. The method or system according to any one of paragraphs 1 to 33, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of at least 1,400 kPa and less than 4,000 kPa.

35. The method or system according to any one of paragraphs 1 to 34, wherein the ethylene is separated from the second hydrocarbon mixture at a pressure of at least 1,600 kPa and less than 4,000 kPa.

Certain embodiments and features have been described using a set of numerical upper limits and a set of numerical lower limits. It should be appreciated that ranges including the combination of any two values, e.g., the combination of any lower value with any upper value, the combination of any two lower values, and/or the combination of any two upper values are contemplated unless otherwise indicated. Certain lower limits, upper limits and ranges appear in one or more claims below. All numerical values are "about" or "approximately" the indicated value, and take into account experimental error and variations that would be expected by a person having ordinary skill in the art.

Various terms have been defined above. To the extent a term used in a claim is not defined above, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent. Furthermore, all patents, test procedures, and other documents cited in this application are fully incorporated by reference to the extent such disclosure is not inconsistent with this application and for all jurisdictions in which such incorporation is permitted.

While the foregoing is directed to embodiments, other and further embodiments of the invention can be devised without

departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

What is claimed is:

1. A method for separating one or more olefins comprising:
 - separating at least a portion of C_3 and heavier hydrocarbons from a hydrocarbon comprising C_1 to C_{20} hydrocarbons and hydrogen to provide a first hydrocarbon mixture comprising methane, ethane, ethylene, acetylene, and hydrogen;
 - hydrogenating at least a portion of the first hydrocarbon mixture to convert at least a portion of the acetylene to ethane and ethylene to provide a hydrogenated mixture, wherein the hydrogenation is performed using contained hydrogen in the first hydrocarbon mixture, optionally supplemented by an external stream with hydrogen concentration of at least 50 mol %;
 - cooling and condensing the hydrogenated mixture, at a temperature ranging from 5°C . to -40°C .;
 - separating at least a portion of the methane from the condensed hydrogenated mixture to provide a second hydrocarbon mixture comprising ethane and ethylene; and
 - separating at least a portion of the ethylene from the second hydrocarbon mixture to provide a first product comprising at least 97 mol % ethylene and a second product comprising at least 97 mol % ethane, wherein the at least a portion of ethylene is separated from the second hydrocarbon mixture using a vapor-liquid separator at a temperature greater than boiling point of propylene, that is greater than about -48°C . and at a pressure of about 360 kPa to about 4,000 kPa, wherein the hydrogenated mixture is cooled using refrigerated propylene.
2. The method of claim 1, further comprising transferring at least a portion of the second product to a pyrolysis furnace.
3. The method of claim 1, wherein the at least a portion of C_3 and heavier hydrocarbons are separated from the hydrocarbon comprising C_1 to C_{20} hydrocarbons at a pressure of about 400 kPa to about 3,000 kPa.
4. The method of claim 1, wherein the at least a portion of methane is separated from the condensed hydrogenated mixture at a pressure of about 600 kPa to about 4,200 kPa, and the ethylene is separated from the second hydrocarbon mixture at a pressure of about 500 kPa to about 2,500 kPa.
5. The method of claim 1, wherein at least a portion of the hydrocarbon comprising C_1 to C_{20} hydrocarbons is produced by cracking a heavy hydrocarbon containing C_{4+} hydrocarbons in a fluid catalytic cracker, a pyrolytic process, or combination thereof.
6. The method of claim 1, wherein the at least a portion of C_3 and heavier hydrocarbons are separated from the hydrocarbon comprising C_1 to C_{20} hydrocarbons at a pressure of about 800 kPa to about 2,000 kPa, the methane is separated from the condensed, hydrogenated mixture at a pressure of about 900 kPa to about 3,500 kPa, and the ethylene is separated from the second hydrocarbon mixture at a pressure of about 500 kPa to about 2,500 kPa.
7. The method of claim 1, wherein the at least a portion of the first hydrocarbon mixture is hydrogenated in the presence of a catalyst.
8. The method of claim 1, wherein a methane concentration in the hydrocarbon comprising C_1 to C_{20} hydrocarbons is less than 12 mol %.
9. A method for separating one or more olefins comprising:

19

compressing a fluid comprising C_1 - C_{20} hydrocarbons, water, one or more acid gases, and hydrogen to obtain a compressed fluid;
 scrubbing at least a portion of the compressed fluid to remove at least a portion of the one or more acid gases to provide a scrubbed fluid;
 separating at least a portion of the water from the scrubbed fluid to provide a dehydrated fluid containing less than 0.5 mol % water, wherein the dehydrated fluid comprises the C_1 - C_{20} hydrocarbons and hydrogen;
 separating at least a portion of C_4 and heavier hydrocarbons from the dehydrated fluid to provide a hydrocarbon comprising C_1 - C_3 hydrocarbons and hydrogen;
 separating at least a portion of C_3 hydrocarbons from the hydrocarbon comprising C_1 - C_3 hydrocarbons to provide a first hydrocarbon mixture comprising ethane, ethylene, acetylene, methane, and hydrogen, where the hydrogen concentration in the first hydrocarbon mixture is from about 0.1 mol % to less than 15 mol %;
 hydrogenating at least a portion of the first hydrocarbon mixture to convert at least a portion of the acetylene to ethane and ethylene to provide a hydrogenated mixture, wherein the hydrogenation is performed using contained hydrogen in the first hydrocarbon mixture, optionally supplemented by an external stream with hydrogen concentration of at least 50 mol %;
 cooling and condensing the hydrogenated mixture, at a temperature ranging from 5° C. to -40° C.;
 separating at least a portion of the methane from the condensed, hydrogenated mixture to provide a second hydrocarbon mixture comprising ethane and ethylene; and
 separating at least a portion of the ethylene from the second hydrocarbon mixture to provide a first product comprising at least 97 mol % ethylene and a second product comprising at least 97 mol % ethane, wherein the at least a portion of ethylene is separated from the second hydrocarbon mixture using a vapor-liquid separator at a temperature greater than boiling point of propylene, that is greater than about -48° C. and at a pressure of about 360 kPa to about 4,000 kPa, wherein the hydrogenated mixture is cooled using refrigerated propylene.

20

10. The method of claim 9, further comprising transferring all or a portion of the second product to a pyrolysis furnace.

11. The method of claim 9, wherein the fluid has a methane concentration of less than 15 mol %.

12. The method of claim 9, wherein the fluid has a hydrogen concentration of less than 15 mol %.

13. The method of claim 9, wherein the at least a portion of C_4 and heavier hydrocarbons are separated from the dehydrated fluid at a pressure of about 500 kPa to about 3,500 kPa.

14. The method of claim 9, wherein the at least a portion of C_3 hydrocarbons are separated from the hydrocarbon comprising C_1 - C_3 hydrocarbons at a pressure of about 400 kPa to about 3,000 kPa.

15. The method of claim 9, wherein at least a portion of the C_1 - C_{20} hydrocarbons is produced by cracking a heavy hydrocarbon containing C_4+ hydrocarbons in a fluid catalytic cracker, a pyrolytic process, or a combination thereof.

16. The method of claim 9, wherein the at least a portion of C_4 and heavier hydrocarbons are separated from the dehydrated fluid at a pressure of about 800 kPa to about 2,000 kPa, the at least a portion of methane is separated from the condensed, hydrogenated mixture at a pressure of about 900 kPa to about 3,500 kPa, and the at least a portion of ethylene is separated from the second hydrocarbon mixture at a pressure of about 500 kPa to about 2,500 kPa.

17. The method of claim 9, wherein the at least a portion of ethylene is separated from the second hydrocarbon mixture at a pressure of about 500 kPa to about 2,500 kPa.

18. The method of claim 1, wherein the hydrogenated mixture is cooled using a chilling system, wherein the chilling system includes a first cooler, a first vapor/liquid separator receiving the cooled hydrogenated mixture from the first cooler, and a second cooler receiving a gaseous hydrogenated mixture from the vapor/liquid separator.

19. The method of claim 18, wherein the first cooler provides a first cooled condensed portion of the hydrogenated mixture, wherein the second cooler includes at least one heat exchanger and a second vapor/liquid separator, and wherein the second vapor/liquid separator provides at least a tail gas and a second cooled condensed portion of the hydrogenated mixture.

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